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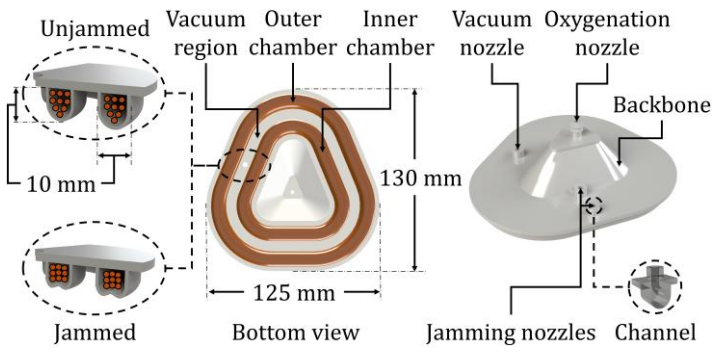
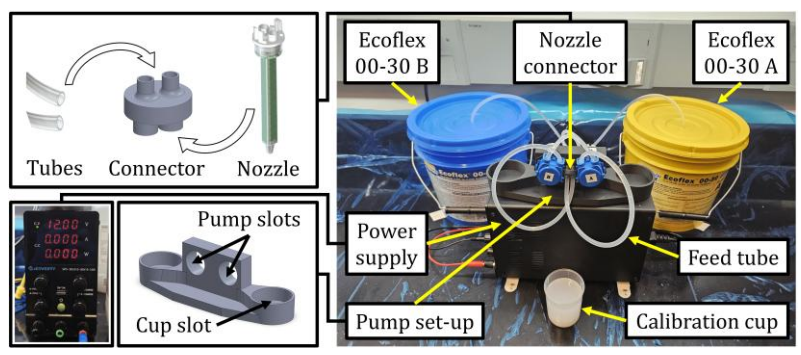
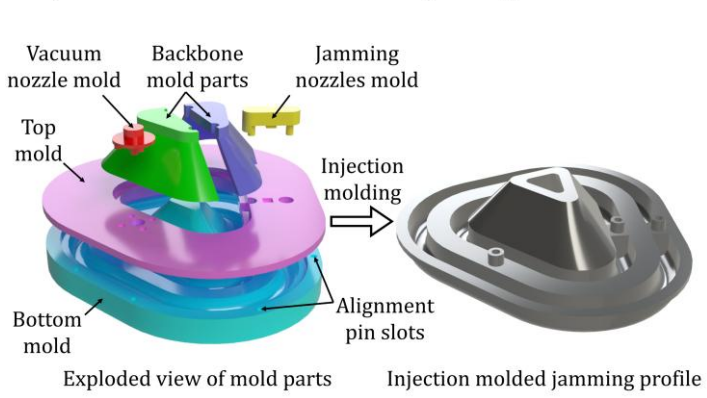
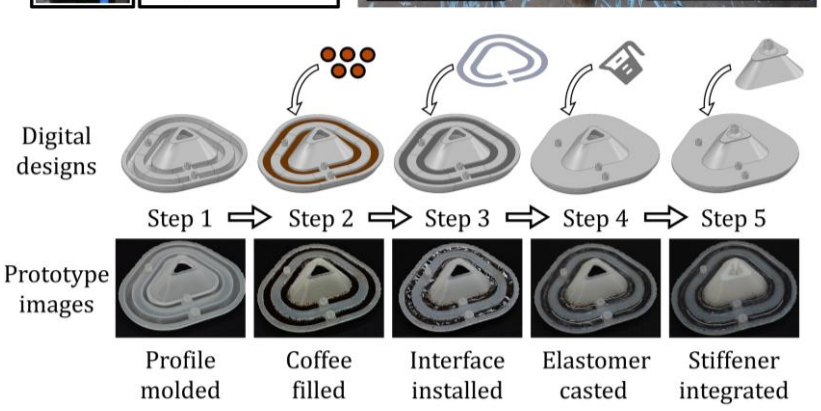
Adaptive Self-Sealing Soft Robotic Face Mask with Particle Jamming









Overview

- A soft robotic mask capable of conforming and adhering to human facial features.
- An improvement on the existing bag valve mask that requires multiple volunteers for installation.

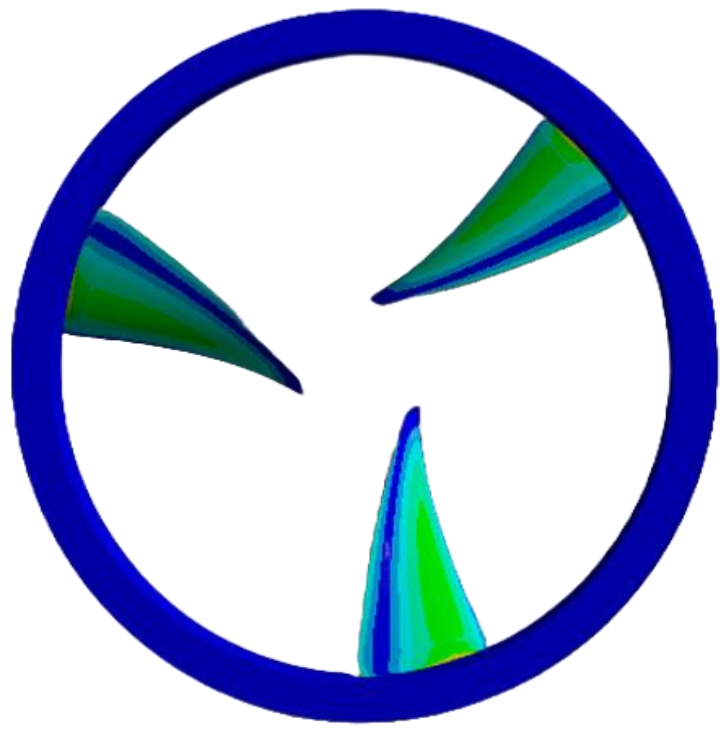
Approach

- The mask design was entirely modelled on **SolidWorks**.
- Elastomer P7600 was used as the soft material.
- A custom developed setup for **injection molding** was used to produce functional prototypes of the mask.

Results

- Manufactured functional mask prototypes composed of jamming profiles with **1 mm** thickness.
- Increased the mask human-safe operation zone by **41**% using active particle jamming, validated by experiments.

Integrated Hydro-Powered Generator-Turbine



Overview

- A novel hydro-powered turbine concept based on a direct-drive system.
- An improvement on turbine designs that possess energy losses due to friction.

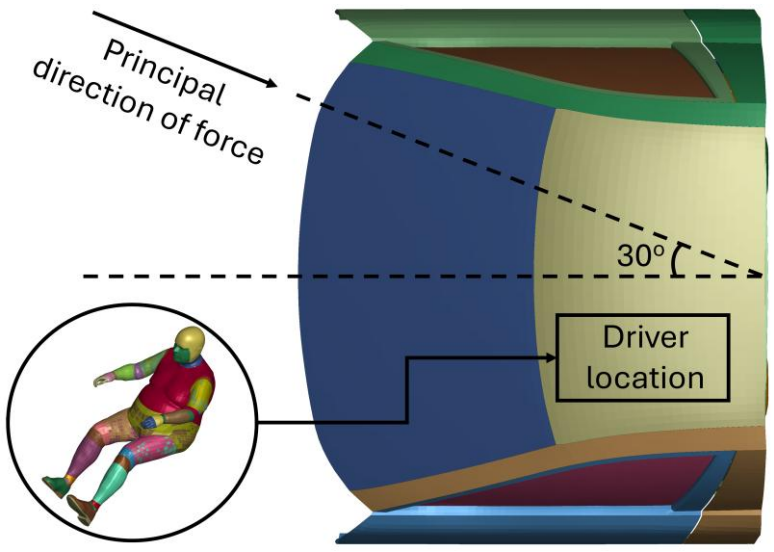
Approach

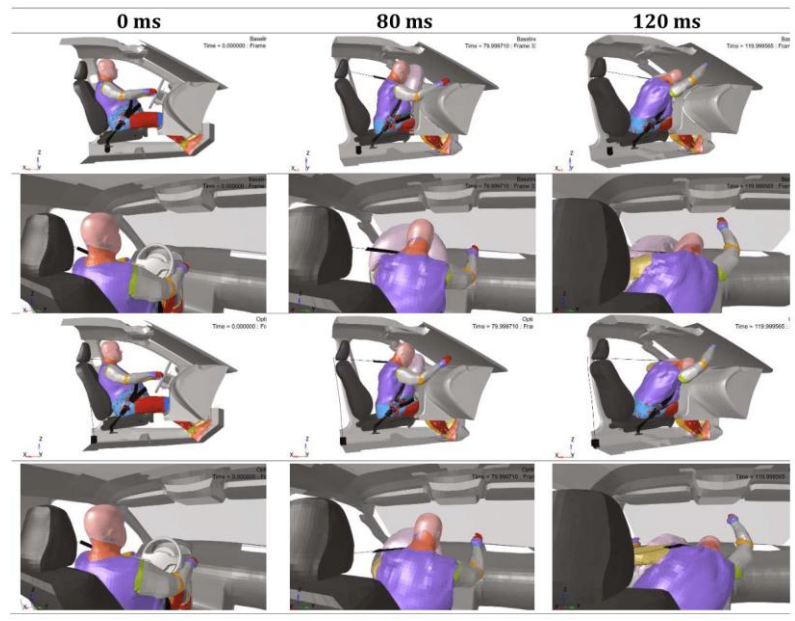
- The turbine assembly including stator, rotor, blades, and ducts were designed on **SolidWorks**.
- Modeling was done while maintaining a constant desired tolerance of **1.5 mm**.

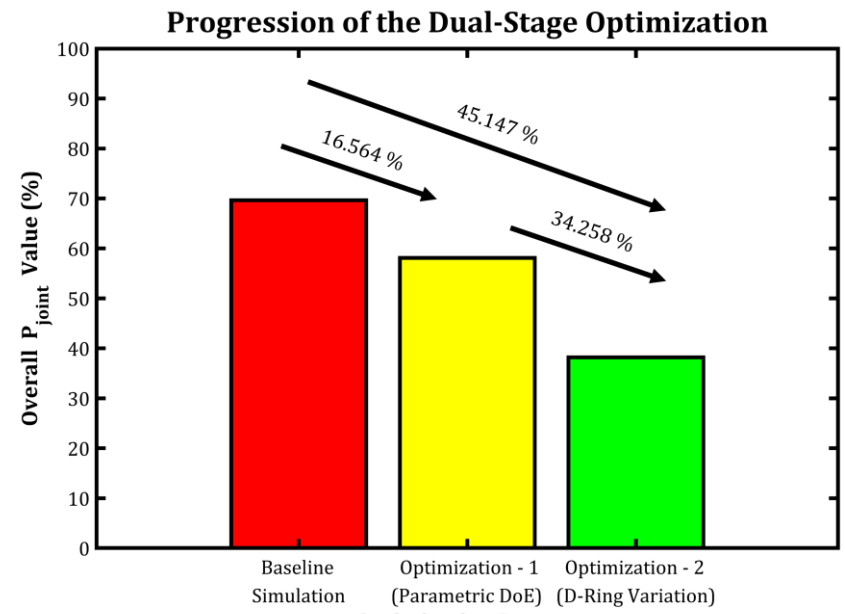
Results

- Achieved a **Factor of Safety** of **2** upon **FEM** analysis of blade design on **Abaqus**.
- Assembled a prototype with **300 mm** turbine diameter using additively manufactured parts.

Design Optimization for Obese Male Driver in Oblique Far-side Impact







Overview

- A **design optimization** to improve occupant protection for an obese aged male driver in an oblique far-side impact.
- Oblique frontal crashes are challenging to design for owing to limited regulation tests and research.

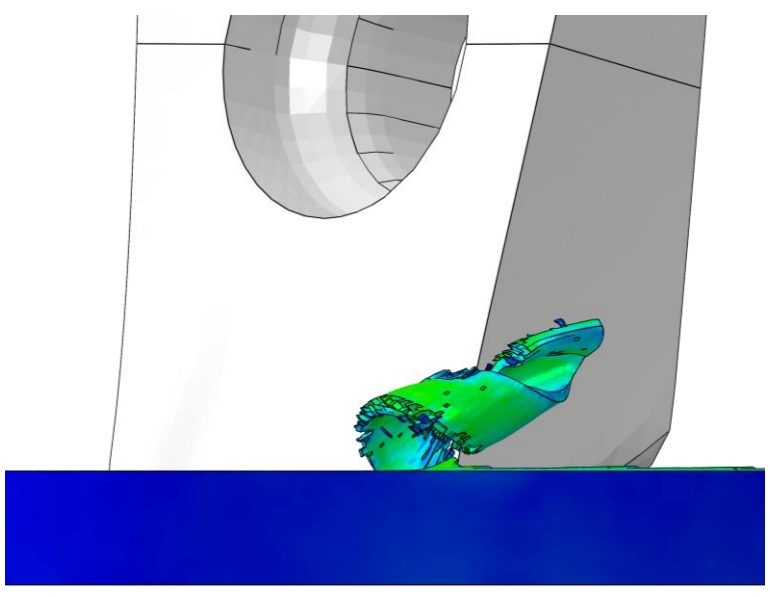
Approach

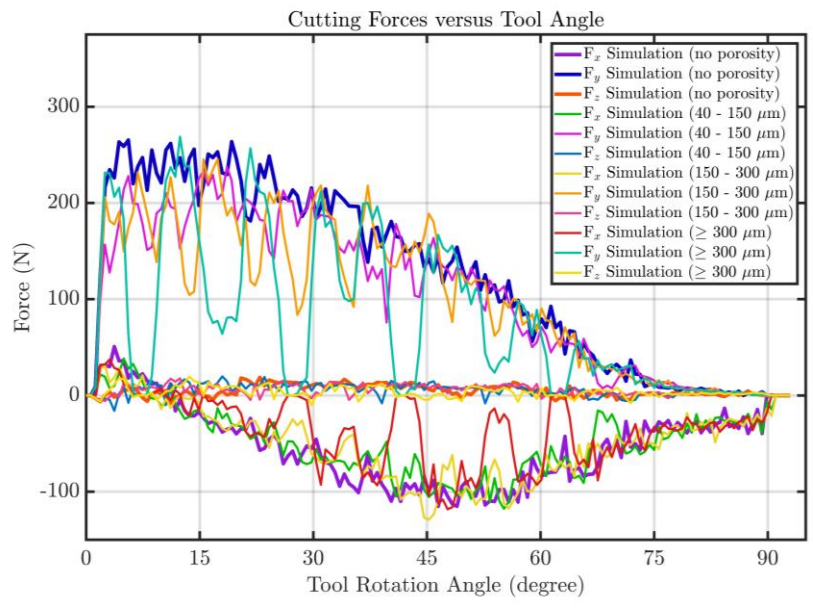
- Utilized **LS-PrePost** for model set-up and **LS-Dyna** for running the simulations.
- Implemented a dual stage optimization process involving a parametric study using **Taguchi method** followed by D-Ring position variation.

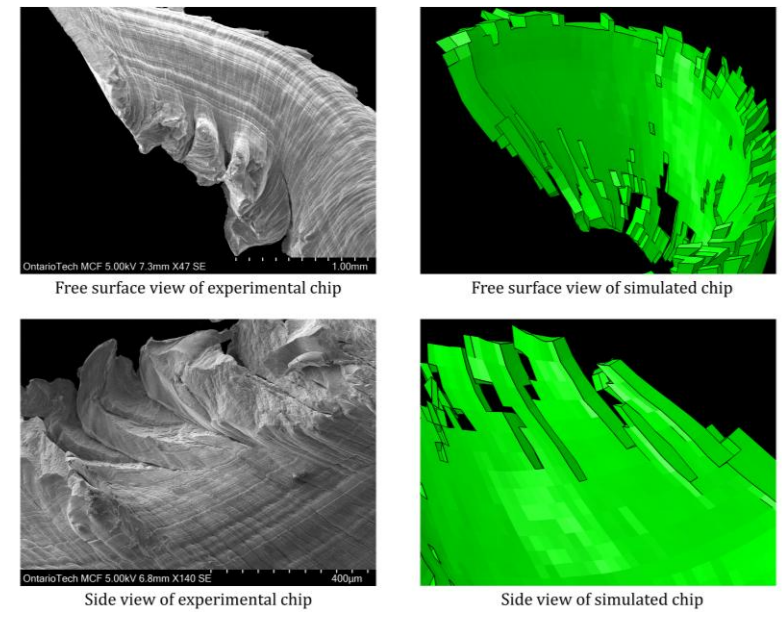
Results

- A total of **27 crash simulations** were run and the joint injury values were investigated .
- Achieved a **45% optimization** by improving the overall occupant kinematics and reducing chest and brain injury risks.

Finite Element Analysis of Milling AM AlSi10Mg with Porosity Defects







Overview

- A novel three-dimensional finite element analysis to model the milling of additively manufactured AlSi10Mg alloy.
- The chip formation is simulated in addition to numerically predicting the cutting forces involved.
- A validated numerical model eliminates the need to perform expensive experimentation.

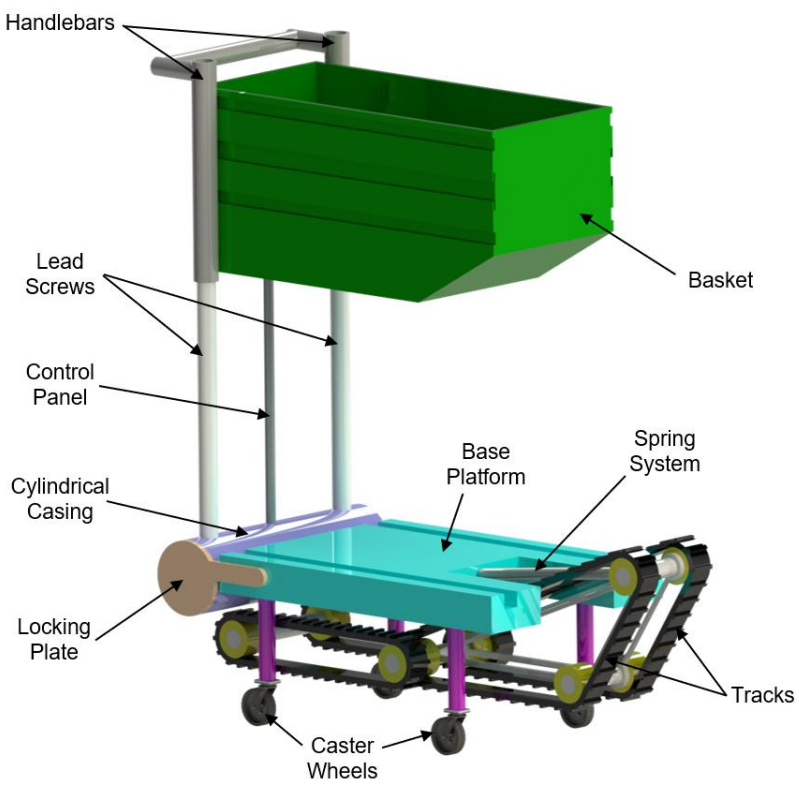
Approach

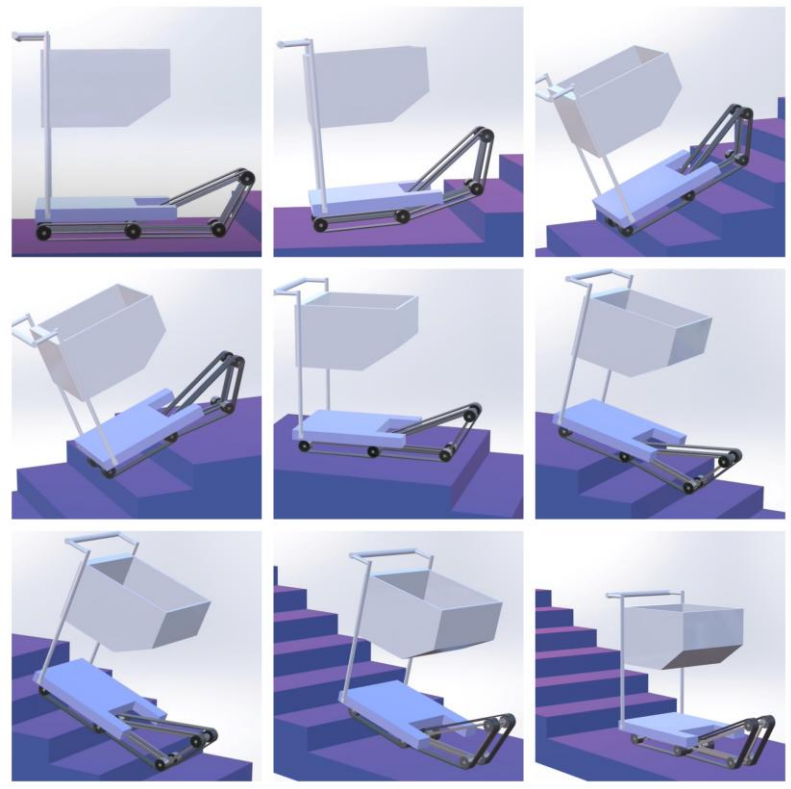
- The numerical simulation models were entirely built on **Abaqus**.
- The finite element models were simulated using the **Explicit Dynamics** solver in the **Temperature-Displacement** domain.
- **Mass scaling** is utilized to accelerate the simulations while preserving the accuracy.

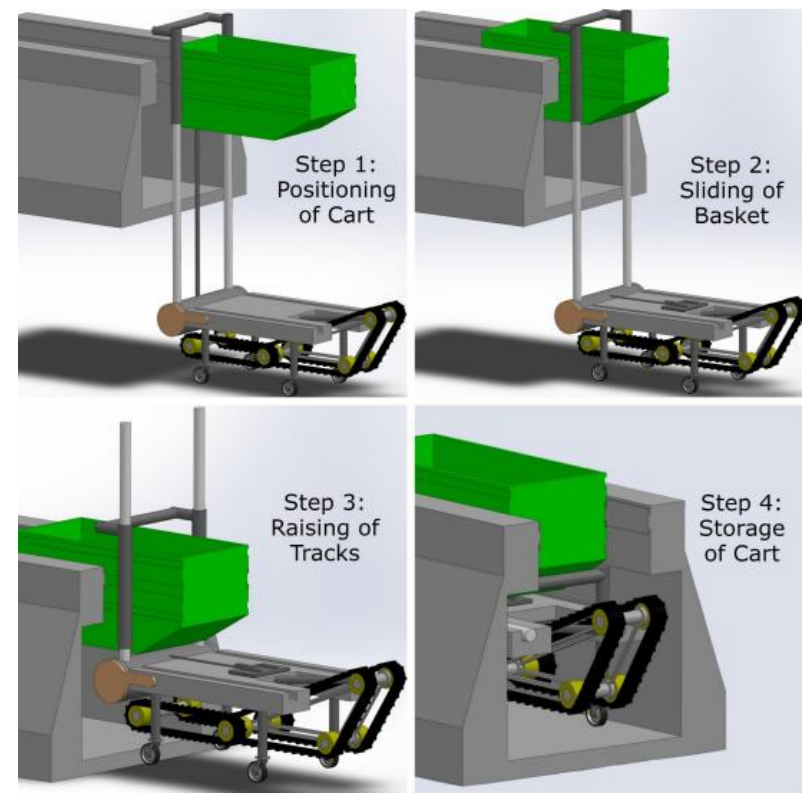
Results

- **Cutting forces** were validated with those obtained from **experimental machining** tests on a HAAS VF2-YT machine.
- **Chip morphologies** were also compared to strengthen the validity of the proposed simulation models.
- Successful study on the **influence of porosity** on the trend of cutting forces.

Stair Trek: Portable Multi-Tracked Stair-Climbing Grocery Cart







Overview

- A semi-automatic stair-climbing groceries cart that can also be stored within the trunk of an automobile.
- Made of three independent systems called stair-climbing system, switching system, and loading system.
- Aimed at improving the grocery shopping experience of the independent elderly.

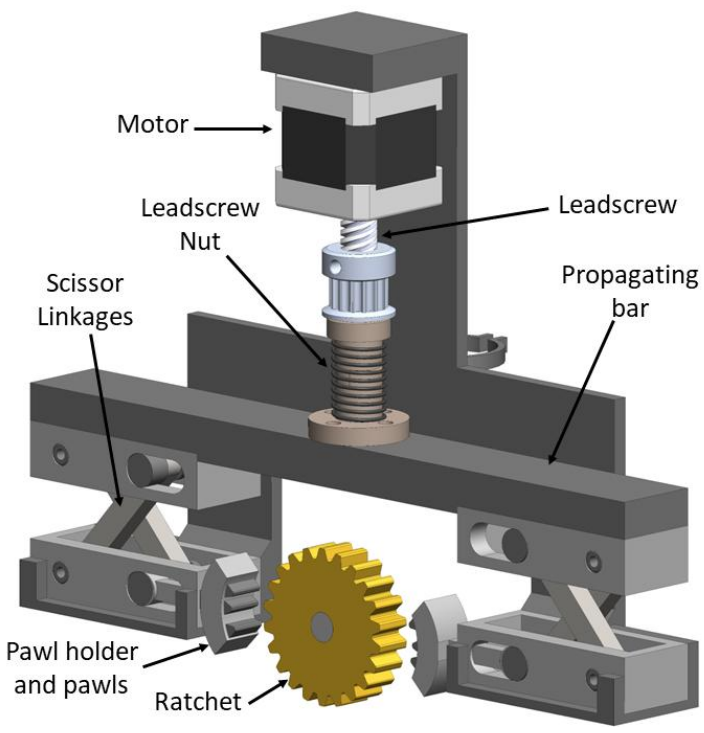
Approach

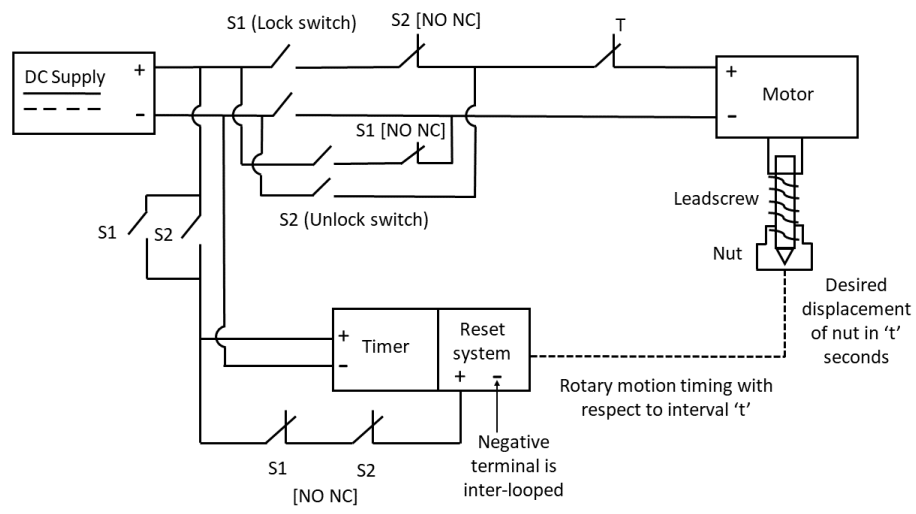
- A review of literature and existing products inspired the track system design.
- The entire assembly of components was modelled on **SolidWorks**.
- Multibody dynamic simulation for stair-climbing action performed on SolidWorks and static analysis for structural integrity on **Ansys**.

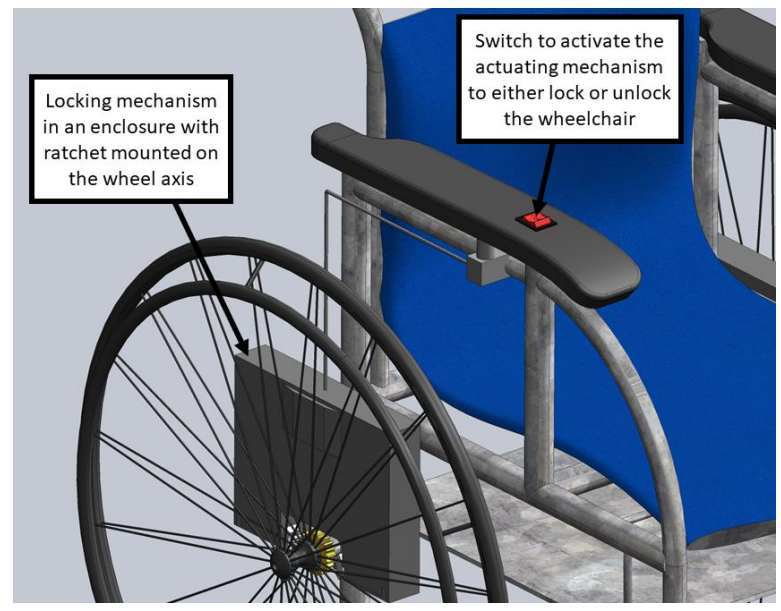
Results

- Analytical calculations for drive torque from a simplified stair-climbing track system were validated by multibody dynamic simulations.
- Motion study animations were developed to demonstrate the loading mechanism.
- Structural integrity during loading action was guaranteed with a **Factor of Safety** of **7.29**.

Statio: Retrofittable Non-Frictional Wheelchair Locking Mechanism







Overview

- A retrofittable non-frictional locking mechanism for manual wheelchairs.
- The lock overcomes frictional inefficiencies and demands little to no actuation force.

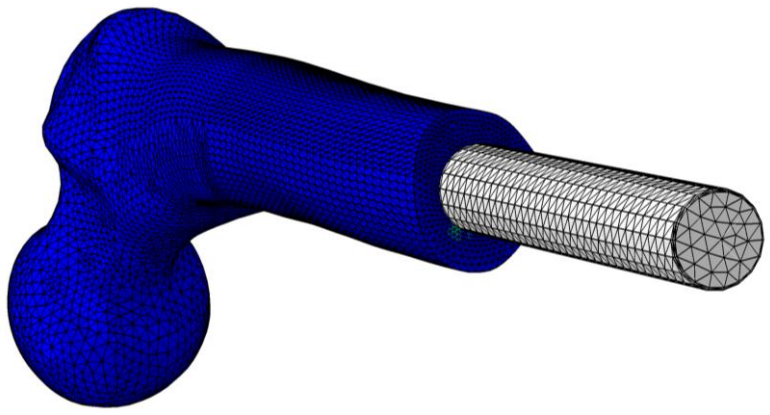
Approach

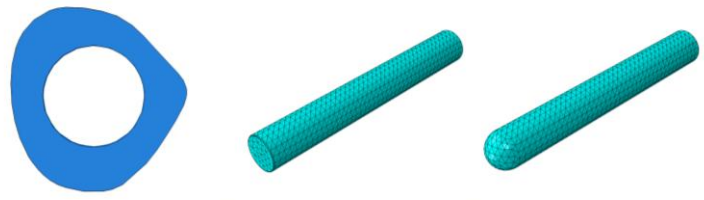
- The entire assembly of components was modelled on **SolidWorks**.
- Successful functioning upon application of loads were verified using **Ansys** analysis.

Results

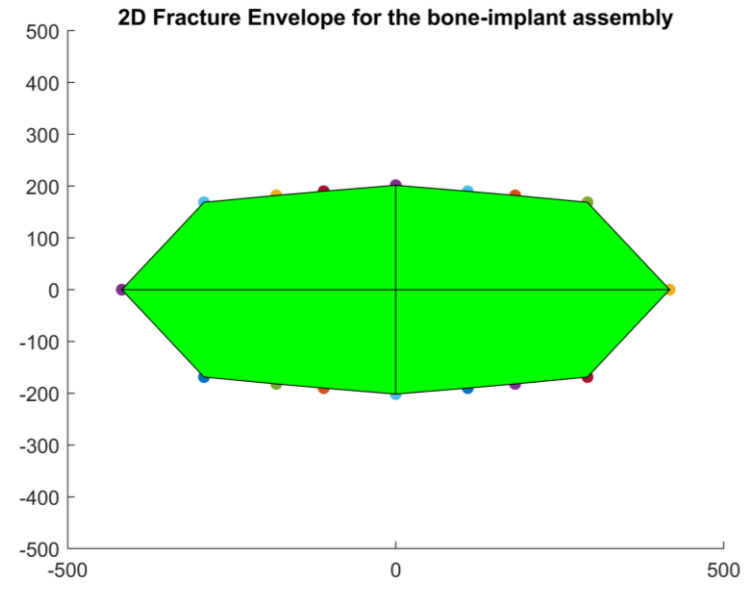
- Analytical calculations of a simplified lead-screw system indicate drive torque of 0.1 Nm.
- A novel multi-slot double-pawl ratchet system independent of wheel orientation.

Finite Element Analysis of Bone-Fixture Joint in Osseointegration





Load \ Implant	Filleted	Rounded
50N (+Y)	80.3 MPa	57.6 MPa
50N (-Y)	100.2 MPa	51.08 MPa
50N (+Z)	77.86 MPa	32.71 MPa
50N (-Z)	36.77 MPa	39.54 MPa



Overview

- A **Finite element model** to model the bone-fixture joint in osseointegration.
- To study the effect of various loads on the joint with the objective of deriving the **optimal fracture envelope**.
- Anisotropic material properties for human femur were chosen to make the simulations realistic.

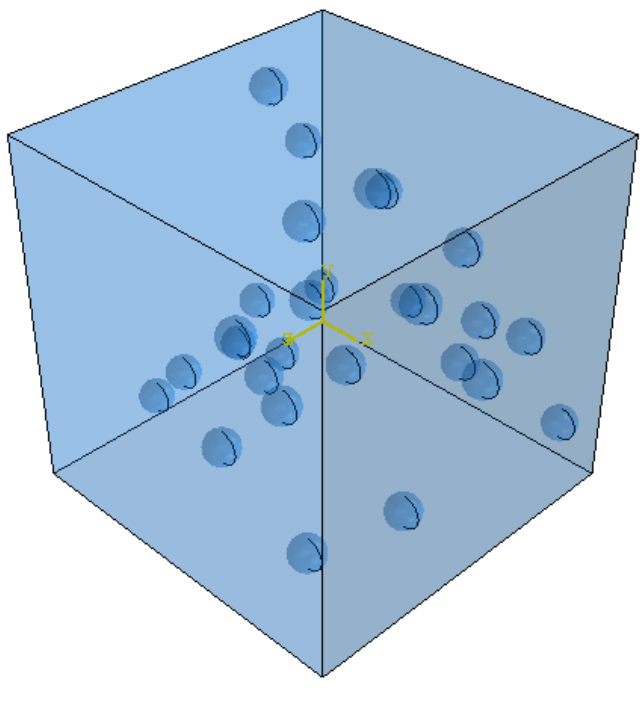
Approach

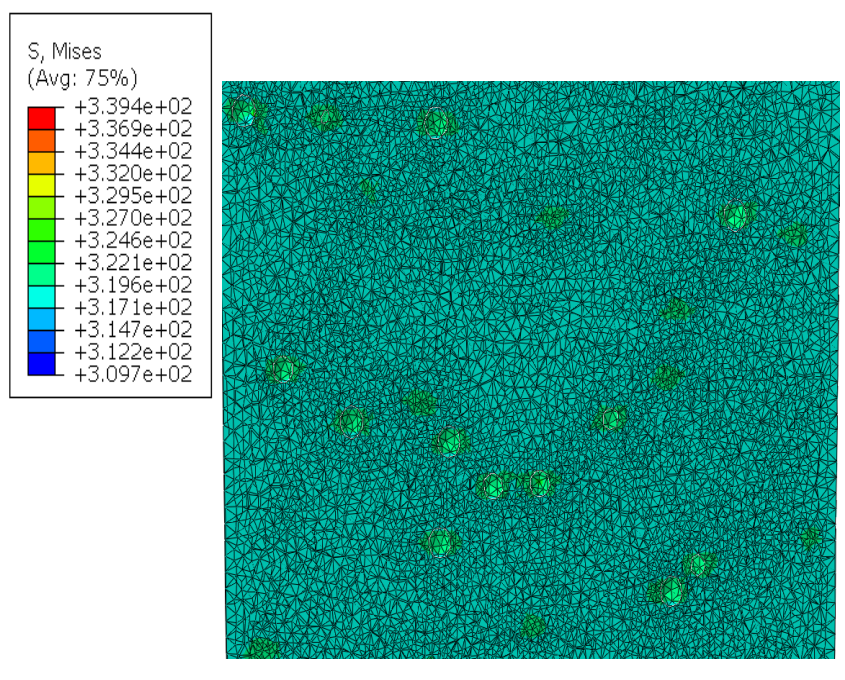
- The entire assembly of components was modelled on **Abaqus**.
- The effect of two different implants on stress distribution was studied involving filleted and rounded ends.
- The fracture envelope was obtained by post-processing the numerical simulation results using **MATLAB**.

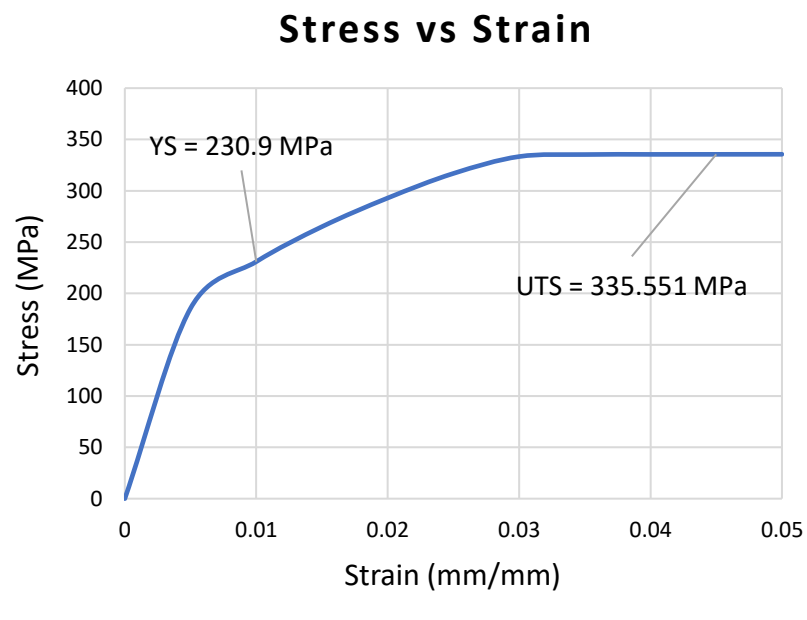
Results

- Python scripting algorithmic modules were developed and integrated into Abaqus to automate the assembly process and run simultaneous simulations.
- Derived an optimal fracture envelope for the joint upon analyzing transverse stresses and reaction forces from simulating 16 load cases.

Finite Element Modeling of Microstructural Porosity







Overview

- A **Finite Element Model** to model microstructural porosity as induced defects of additively manufactured AlSi10Mg parts.
- To study its effect on the mechanical properties like yield strength and ultimate tensile strength.
- Mathematical model to reduce dependency on practical tests.

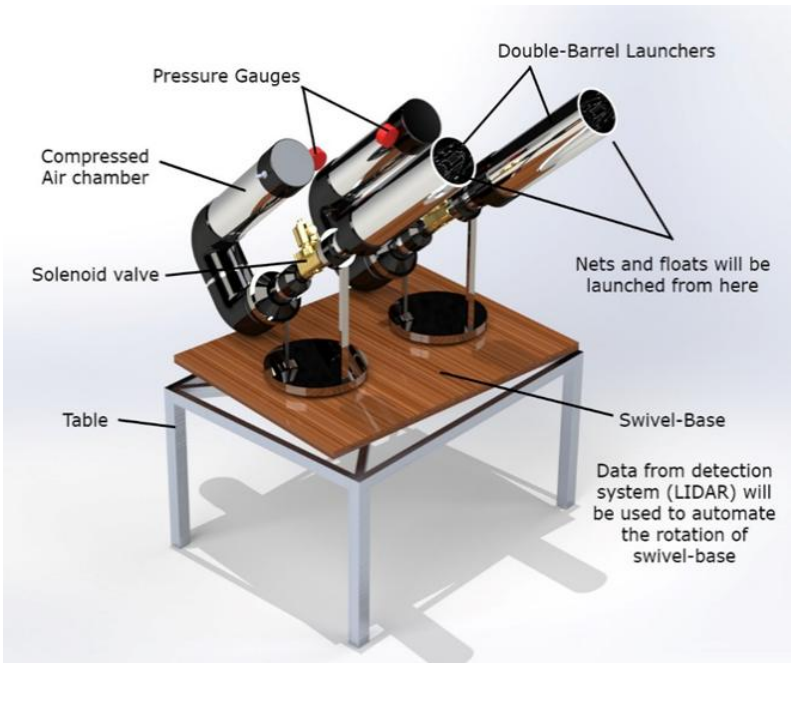
Approach

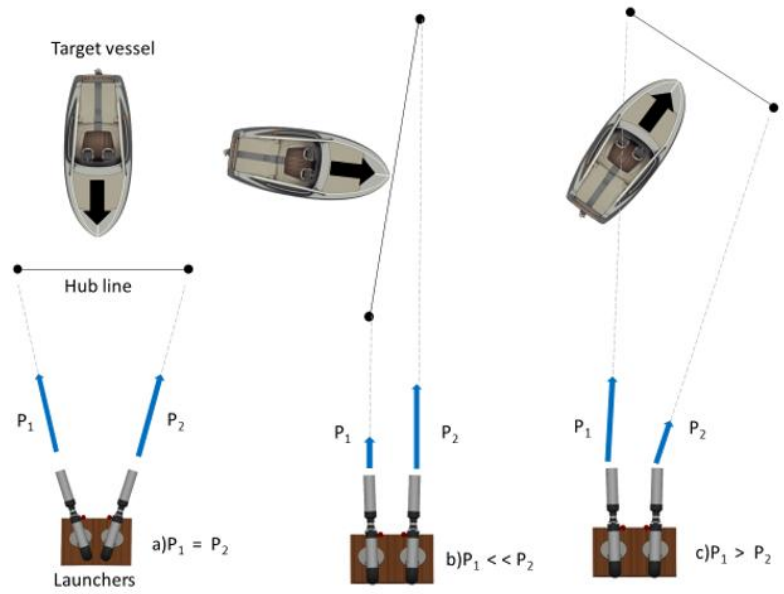
- **Python scripting** coupled with **Abaqus** to integrate computer programming with finite element analysis.
- Developed an algorithm to automate the modelling of porosity with user-defined variables.
- Random pores with non-uniform size and distribution using iterative approach.

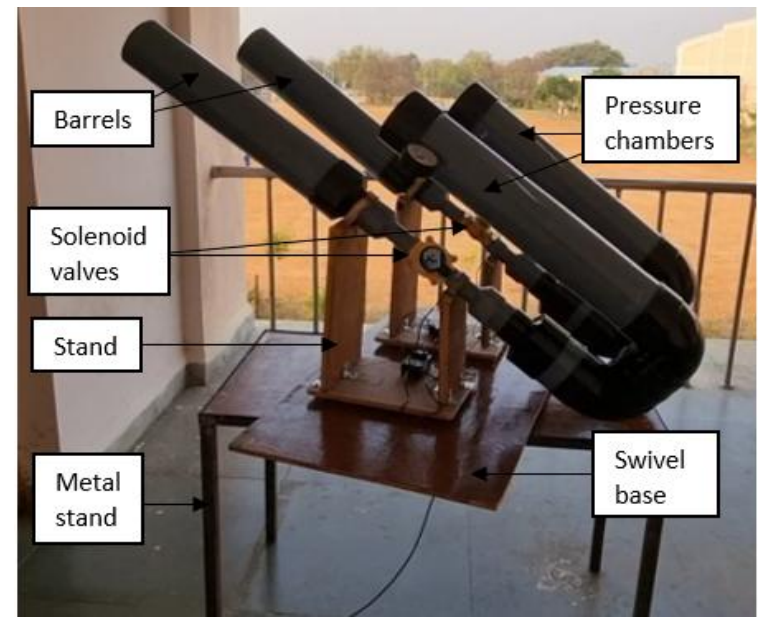
Results

- The numerical model was validated with experimental data obtained from literature.
- The simulation results reported yield strength and ultimate tensile strength of 230.9 MPa and 335.551 MPa indicating **99.84% accuracy**.
- Pathway for machine-learning to eliminate experimental tests was envisioned.

C-BASS: Controlled Boat Anchored Ship Stopper







Overview

- A semi-automatic non-lethal system to prevent maritime vessels from invading or evading naval perimeters.
- The solution is targeted at improving the defense technology at the Indian Navy to better the present methodology of dealing with trespassing of unauthorized vessels.

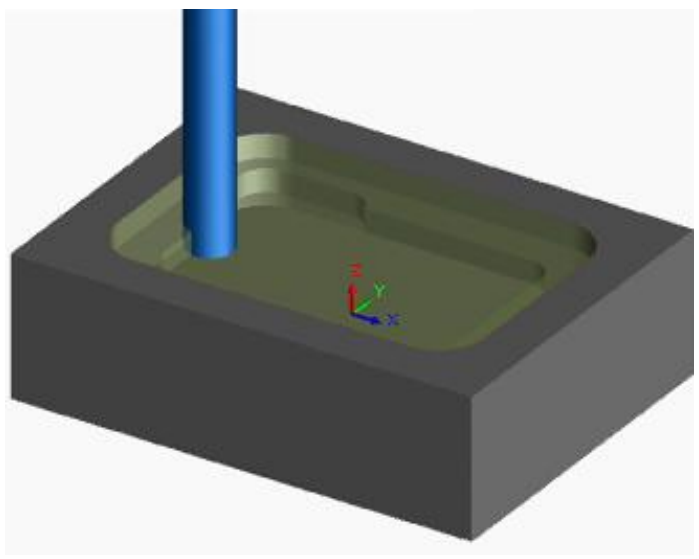
Approach

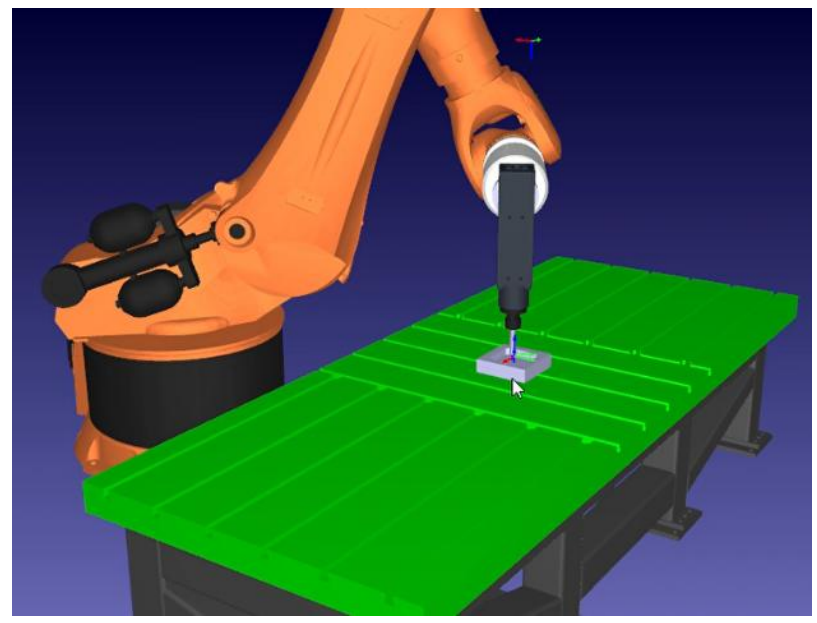
- The entire assembly of the design was modelled using SolidWorks.
- Hydrodynamic simulations to determine the shape of the hydrofoil were performed on **FoilSim**.
- Reduced scale prototype of functioning model was fabricated and assembled to test the workability.

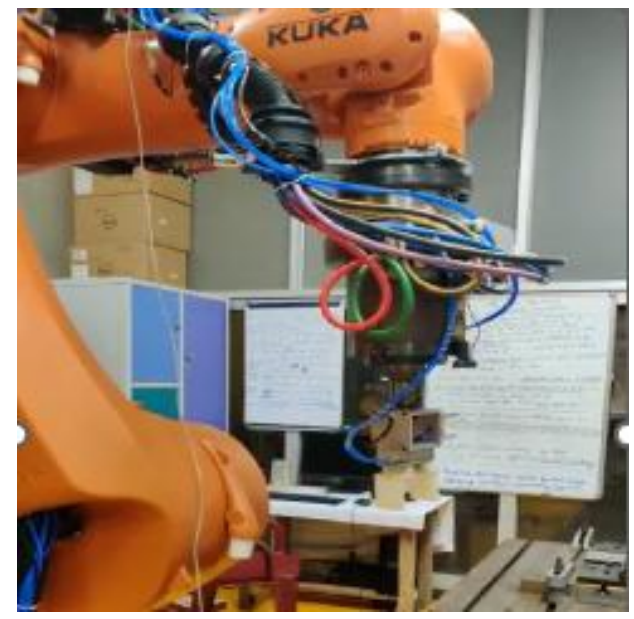
Results

- A double-barrel pneumatic launcher system allows targeting vessels approaching from any direction.
- An RP-LIDAR driven detection system was developed to trace vessels that evade on-board radar systems.
- The prototype could launch nets **120 m** far with a working pressure range of **25 PSI**.

Robot-based Manufacturing







Overview

- A process flow to convert the G-Code to KRL language to machine a desired design with the help of a robot arm.
- The higher number of degrees of freedom with a robot arm as compared to a CNC machine is leveraged.

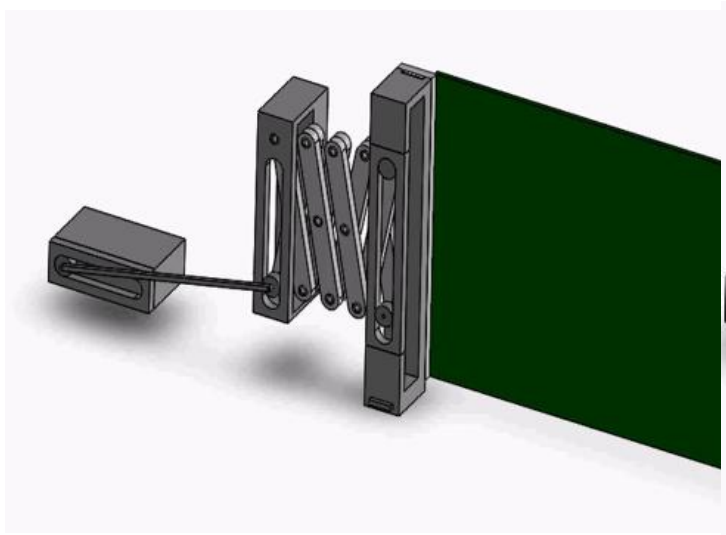
Approach

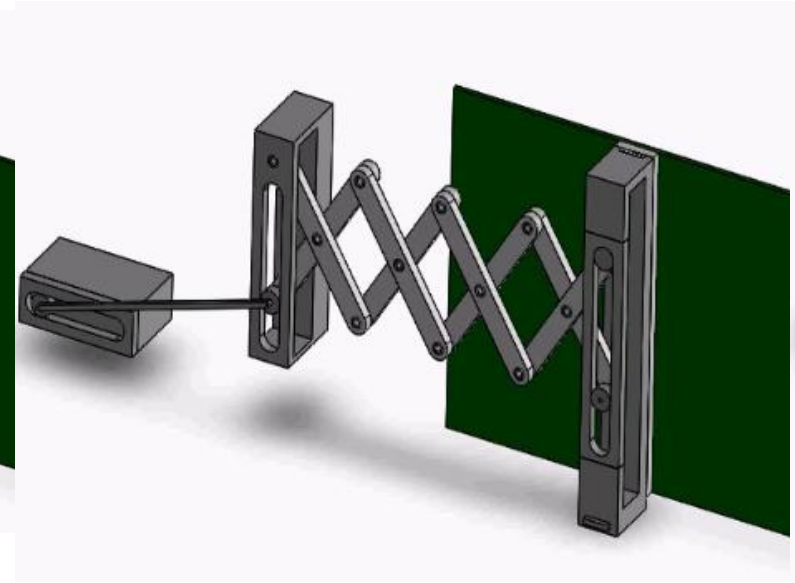
- G-Code for machining the desired part was derived from **SolidWorks** using the built-in **CAM Module**.
- The workstation was replicated on **RoboDK** to simulate the machining operation using robotic arm.

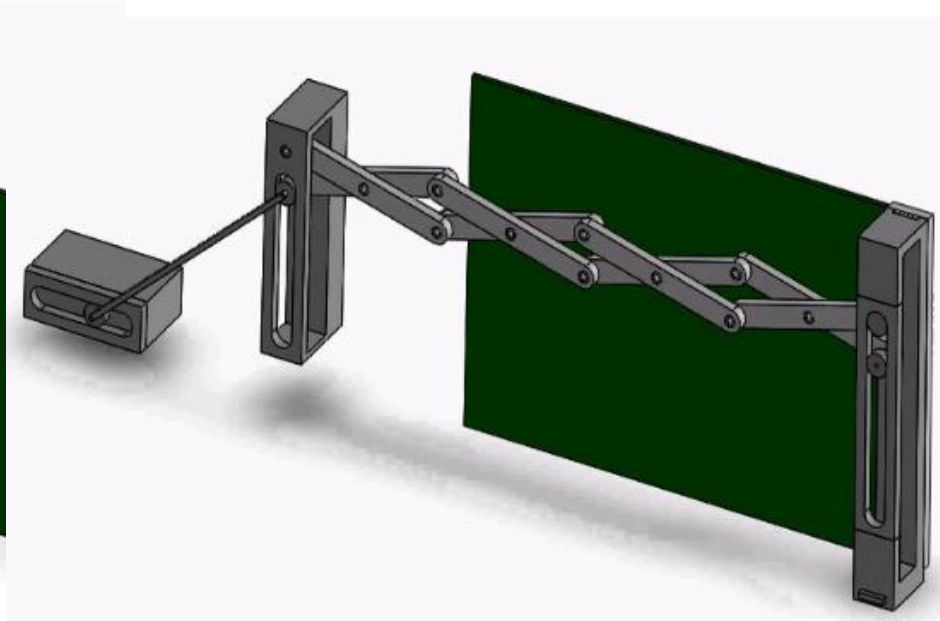
Results

- The KRL language converted from the G-Code using the replicated workstation set-up on RoboDK was used to run a **KUKA KR 500 R2830** robot.
- An algorithm to automate the conversion of part file to G-Code was envisioned.

One-Sweep: Pantographic Blackboard Dusting Mechanism







Overview

- A pantographic manually driven blackboard dusting mechanism that achieves a clean board with one sweep of the duster.
- The solution is targeted at reducing the time required and the number of dusting strokes used to wipe a board clean.

Approach

- The entire assembly of the design was modelled using **SolidWorks**.
- The working of the product was visualized and understood using the **Motion Study** tool in SolidWorks.
- Multiple simulations to determine optimal positioning of subsystems.

Results

- An easy to actuate mechanism was developed to allow simple cleaning of the blackboard in classrooms.
- The system is designed to have mechanical advantage to allow conversion of small physical human inputs to enlarged linkage outputs in terms of motion.